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AEROMEDICAL APPRAISAL OF F4H-1/SPARROW III WEAPON SYSTEM

By

G. G. LUCCHINA and C. G. PHIPPS
Bio-Medical Division

29 June 1962

U. S. NAVAL MISSILE CENTER
Point Mugu, California

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AN ACTIVITY OF THE BUREAU OF NAVAL WEAPONS

K. C. CHILDERS, JR., CAPT USN
Commander

This report describes work accomplished under WEPTASK RM-37210, Navy Evaluation of SPARROW III (XAAM-N-6a/F3H-2/F4H-1), Task N01.

LCDR H. W. Egan, SPARROW III Project Officer, CAPT V. W. Lyon, Life Sciences Officer, and Mr. E. Q. Smith, Director of Laboratories, have reviewed this report for publication.

Approved by:
D. F. SULLIVAN
Technical Director

THIS REPORT HAS BEEN PREPARED PRIMARILY FOR TIMELY PRESENTATION OF INFORMATION. ALTHOUGH CARE HAS BEEN TAKEN IN THE PREPARATION OF THE TECHNICAL MATERIAL PRESENTED, CONCLUSIONS DRAWN ARE NOT NECESSARILY FINAL AND MAY BE SUBJECT TO REVISION.

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TABLE OF CONTENTS

SUMMARY

Aeromedical appraisal of the F4H-1F/SPARROW III weapon system was undertaken to detect any weakness in the human factor as part of the weapon system complex.

Results of a questionnaire submitted to pilots and radar operators regarding deficiencies in the Mark IV full pressure suit are discussed. Problems arose in respect to mobility in the pressurized state, visibility, and in mating the g-suit hose with the full pressure suit. Recommendations for solutions to the problems are included.

In-flight monitoring of physiologic parameters was accomplished and a discussion of results is included with implications to possible detrimental effects on participants.

INTRODUCTION

The objective of the part played by the Bio-Medical Division of the Life Sciences Department in the evaluation of the F4H-1F/SPARROW III weapons system under BUWEPS WEPTASK RM-37210, task N01, was the aeromedical appraisal of the subject system with particular emphasis on stresses which might be incurred in the operational environment and on problems which might arise in the life-support system. The philosophy behind such an investigation is the consideration of men as integral components of the above and any weapon system, and that man, by his very nature, is limited and certainly not infallible. Therefore, any data which might be compiled which would foretell and allow correction of the human factor link in a weapon system should be obtained.

The general plan of this investigation was to follow two simultaneous paths. One phase evaluated the life-support gear in the F4H with particular emphasis on the Mark IV full pressure suit through personal contact with pilots, radar operators and other personnel involved in the evaluation, and also through a questionnaire inviting comments from participants which was filled out before and after each flight in which the full pressure suit was worn. The other path of investigation involved in-flight observation of various physiological functions of pilots and radar operators during operational missions involving the subject weapons system. This was accomplished by magnetic tape recording of physiological parameters during various phases of flight profiles.

Procedures followed and results obtained by the above methods will be described below.

MARK IV FULL PRESSURE SUIT EVALUATION

The bulk of data obtained concerning problems in use of the Mark IV full pressure suit was through the evaluation of the results of the questionnaire reproduced in figure 1. As noted above, this questionnaire was filled out prior to and after each flight by all participants wearing the full pressure suit. At this time they were also interviewed concerning problems which might not be listed in the questionnaire. In general, it was found that, although the interviews were important in clarifying issues, most problems were covered in the questionnaire.

Evaluation Results

The first 12 items of the aeromedical questionnaire involved such details as participant's name, date, type of aircraft flown, flight code number, and operational number. Pertinent data here is that since the initiation of this form, 11 pilots and radar operators have participated in this investigation representing a total of 58 wearings of the Mark IV full pressure suit, 53 of which were in the F4H, 4 in the F3H, and 1 in the F9F. It should be noted that all items in this questionnaire were not answered by all participants in the program and hence the discrepancy in the total number of data points from item to item.

CONFIDENTIAL (when filled in)

1. Pilot/RO Name
A. L.
B. Bucknum M.
C. Campbell, J. N.
D. Bierhaalder O.
E. Ewing P. Johnson, P.
F. Elliott, B. Q.
G. Githens, D. R.
H. Hales, P. S.
I. T. Brown, T.
J. Elliott, W. U.
K. Kelly, F. V.
W.

2. Month
1. Jan 5. May 9. Sep
2. Feb 6. June A. Oct
3. Mar 7. July N. Nov
4. Apr 8. Aug D. Dec

3. 4. Day

5. Year (last digit only)
1 - 1961 4 - 1964

6. Type Aircraft
1. FJ 4. F4H 7. F4D
2. TV 5. 8. F8U
3. F3H 6. A4D 9. F9F

7. 8. 9. Flight Code Number

10. 11. 12. Op Number

13. 14. Time Suit Worn (Hrs & Tenths)

15. 16. Time required to Don Pressure Suit (Hrs & Tenths)

17. 18. Temperature in Donning Area (Degrees in farenheit)

19. 20 Runway Temperature (Degrees in farenheit)

21. Method of ventilation during transport to aircraft
U. Unsat. See remarks
N. None
S. Sawyer unit
T. TAC truck
A. Air Research Unit
J. Jet starter
2. NR2
3. NR3

22. Method of ventilation during preflight walkaround (Same code as item 21)

23. Method of ventilation prior to turn-up (Same code as item 21)

24. Difficulty/delay in strapping in:
1. Upper block assembly
2. Exhaust connection
3. O_2 connections
4. Ventilation
5. Communications

25. Suit ventilation after turn up and in flight (Remarks Requested)

26. Communications adequacies (Use same code as item 25)

27. Suit pressurization
N. Not pressurized
P. Planned pressurization
U. Unplanned pressurization

28. 29. 30. Suit altimeter reading
00.0 -Not pressurized
PP.P -Pressurized (No alt. reading)
33.5 -33,500 feet
36.5 -36,500 feet

31. If suit was pressurized were you or could you
1. Control aircraft
2. Perform intercept
3. Reach/operate ALL SW.
4. Eject
5. All of above
6. All but #1
7. All but #2
8. All but #3
9. All but #4
A. 1 & 2 only
B. 1 & 3 only
C. 1 & 4 only
D. 2 & 3 only
E. 2 & 4 only
N. None of the above

32. Mobility in non-pressurized suit
1. Sat
2. Unsat, generally/two or more of below items
A. Restricted arms
S. Restricted shoulders
C. Restricted chest
W. Restricted waist
K. Restricted crotch
L. Restricted legs
H. Restricted head
R. Restricted wrist
N. Restricted knees
F. Restricted fingers

33. Chaffed areas and/or pressure points caused by suit.
1. None
2. Head
3. Neck
4. Left arm
5. Right arm
6. Both arms
7. Torso
8. Waist
9. Crotch
A. Left leg
B. Right leg
C. Both legs
D. Left knee
E. Right knee
F. Both knees
G. Left wrist
H. Right wrist
I. Both wrists
K. Combination of 2 or more of above

34. Compare vision to APH-5/A13A02 mask
S. Superior
Inferior by reason of:
1. Refraction
2. Reflection
3. Fogging
4. Mobility
5. All of above
6. All but #1
7. All but #2
8. All but #3
9. All but #4
A. 1 & 2 only
B. 1 & 3 only
C. 1 & 4 only
D. 2 & 3 only
E. 2 & 4 only
N. None of above

35. Hours of sleep last night
1. 1 hour
2. 2 hours
A. 10 hours
B. 11 hours

36. Duty hours today, prior to flight. Use same code as item 35.

37. Elasped time you had eaten any foods prior to flight. Use same code as item 35.

38. What did you eat?
1. Sandwich/cold drink
2. Sandwich/milk
3. Sandwich/coffee
4. Light/hot meal
5. Heavy/hot meal
6. Sandwich/cake
7. Sandwich only
8.
9.

39. 40. Total flight time today
06. 6 tenths
18. 1 and 8 tenths

41. Peroid of max stress during flt.
1. Preflight
2. Intercept
3. Reattack
4. Other inflight
5. Landing
6. G maneuvers
7. Take off
8.
9.
A.

42. If possible subjectively evaluate stress
1. Mostly physical
2. Mostly mental
3. Mostly psychological
4. Minimum stress/no evidence of excitation
5. Moderate stress with some subjective increase in respiratory & heart rate
6. Moderately severe stress with definite subjective evidence of excitement, but without apparent deterioration of performance
7. Severe stress with obvious deterioration of performance

43. Problems which might conceivably have decreased your performance on this mission
N. None
E. Emotional
P. Physical
C. Confidential (See Med report)

Figure 1. Questionnaire Completed by All Flight Participants Employing the Mark IV Full Pressure Suit.

Items 13 through 16 of this form obtained data concerning total duration of time the suits were worn and time required to don the full pressure suit. It was noted that the suits were worn from 1.2 to 4.0 hours with an average falling around 2.0 hours, and an average of 12 to 18 minutes being required to don each suit.

Items 17 through 23 involved data concerning temperature in donning areas, runway temperatures, and methods of ventilation. It was noted that temperature in the donning area varied from 68 to 80°F with an average of around 75°F. Runway temperature ranged from 60 to 85°F. TAC truck ventilation was utilized by 37 to 44 full pressure suit wearings during transport to the aircraft. During pre-flight walk-around, the TAC truck was used during 4 full pressure suit wearings, while in 40 wearings no ventilation was used. Prior to turnup, TAC truck facilities were utilized in 22 instances while in another 22 no ventilation was used.

Item 24 required that participants enumerate any difficulty or delay in strapping in. Of 36 answers to this question, 31 reported that they experienced no delay in strapping in, while 3 reported a delay due to trouble making their exhaust connection, and 1 reported difficulty in mating his oxygen connections in the upper and lower block assemblies. One participant noted that in one hop his life jacket was donned with seat straps and lower-lap connectors reversed which forced him to leave the aircraft in order to effect a correction.

The subject of item 25 is suit ventilation after turnup and in flight. Of 44 replies to this question, 43 reported that suit ventilation was entirely satisfactory after turnup, while 1 reported "a hot spot on top of his helmet." The latter participant also noted that the particular hop during which he reported this hot spot was his first pressure suit hop in 4 months and that the difficulty was the fault of his particular suit and was immediately corrected.

In item 26, the participants were asked to comment regarding communications adequacy in the F4H while wearing the full pressure suit, and of 44 answers to this question, 42 reported satisfactory communications while 2 answers obtained, incidentally, from the same participant, reported unsatisfactory communications. In this latter case, the inadequacies again were found to be a fault of the personal flight gear and were corrected.

Items 27 through 31 involved comments concerning function of the Mark IV full pressure suit while in a pressurized state. Item 27 supplies data on how many in-flight pressurizations of the suit were accomplished. Of 44 answers to this question, it was revealed that only on 6 occasions was there any pressurization of the Mark IV full pressure suits and each one of these were planned pressurizations. During 5 of these 6 pressurizations, the suit functioned normally and suit altimeter readings were between 35,000 feet and 35,500 feet. On the other occasion when cabin pressure was dumped and cabin altitude read 45,000 feet, the suit was pressurized only momentarily and then deflated while

the suit altitude reading was 39,000 feet. It was learned after this hop that the main overshoulder zipper had parted for approximately 1 inch and that 8 to 10 teeth along this segment were not meshed. This was considered to have been a structural and maintenance problem and has been corrected.

Item 31 asks the following question, "if suit was pressurized were you, or could you" and then lists several procedures which should be performed if the need arose, such as control aircraft, perform intercept, reach/operate all switches, eject, and various combinations of the above. Answers to these questions were interesting in that of the 6 suit pressurizations, 1 pilot was involved 3 times. His answers were that on one occasion he could have done all of the above and on 2 of the occasions he could have done none of the above procedures. After questioning, this pilot stated that his two negative answers were obtained after flights involving "idiot loop" launch maneuvers and he felt that pressurization precluded this maneuver. He felt that straight-on intercept could be accomplished while pressurized. Of the other answers obtained to the above question from individuals who underwent pressurization, one radar operator stated that he could have done none of the above, one stated that he could have done all of the above, and the other stated that he could have performed intercept although he could not reach and operate all switches and could not have ejected. Four of the participants on returning from missions involving 21 wearings of the full pressure suit during which they did not pressurize the suit, endeavored to answer item 31 and stated that they did not believe that they would be able to perform any of the above-mentioned procedures in a pressurized state.

Item 32 required information regarding mobility in a non-pressurized suit and of 43 answers to this question, 42 were affirmative in that they stated that mobility in the non-pressurized Mark IV full pressure suit was entirely satisfactory. Two answers, both from the same radar operator on successive hops, stated that he thought mobility in the non-pressurized suit was compromised because it restricted motion of his head during these hops. It was later found that the neck ring of his Mark IV full pressure suit was sprung and this was corrected.

Item 33 inquired as to the occurrence of chaffed areas and/or pressure points caused by the Mark IV pressure suit. Of 44 answers to this inquiry, 40 gave negative answers while 4 related that there were pressure points about the head. Later inquiry revealed that the pressure points were related to the face seal and earphones.

The field of vision in the Mark IV pressure suit as compared to vision while wearing the APH-5/A13A helmet/oxygen mask combination was the subject of the inquiry in item 34. Of 39 answers to this question, 20 stated that the visual field in the Mark IV full pressure suit was superior to the APH-5/A13A combination. Of the remainder, 12 thought that the Mark IV visual field was inferior because of reflection, 6 because of fogging and 1 because of mobility. It should be noted that several of the participants reported that, although they considered

the visibility in the helmet of the Mark IV full pressure suit superior to the combination mentioned above, there was a considerable amount of moisture accumulating inside the faceplate, although this did not severely interfere with their mission.

The remainder of the aeromedical questionnaire consists of questions relating to the personal habits of the participants and relates more closely to their physical state during participation in the program. Therefore these data will not be included in this report. It should be mentioned, however, in interviewing participants before and after these flights, several noted that there is considerable difficulty in achieving satisfactory hookup of their g-suit hose through the Mark IV full pressure suit. On several instances, the g-suit hose became uncoupled in flight due to improper pre-flight hookup with subsequent loss of any beneficial functions the g-suit might provide.

Comments

It seems that problems with the Mark IV full pressure suit which were covered in the above-mentioned questionnaire fall into three general categories. The first of these categories involves routine maintenance, which does not fall within the scope of this report.

The second area of difficulty is that of mobility of the Mark IV full pressure suit. When their suits were deflated, most of the participants in this program considered that their mobility was not significantly impeded and that at least subjectively the ventilation of the suit was adequate. However, a great majority of the participants felt that if the suit were pressurized they would not be able to accomplish their mission and in most cases might lose the aircraft and crew. The fact that one pilot was involved in several pressurizations and felt that on one occasion he could have controlled the aircraft and completed his mission while on two other occasions that he could not have accomplished complicated maneuvers, points up the fact that the question of function in a full pressure suit which is pressurized is a matter of proper fit and adjustment, the pressure differential in and out of the Mark IV full pressure suit, and the task to be accomplished. General consensus was that an intercept could be accomplished but all switches could not be reached and complex maneuvers were precluded.

Finally, specific problems were encountered in visibility and in proper use of g-suit while flying in the Mark IV full pressure suit. Most of the participants felt that the visibility in the Mark IV full pressure suit helmet was superior to the visibility encountered while wearing the APH-5/A13A helmet/oxygen mask combination except for difficulty with various reflected images on the faceplate and more often, fogging of the faceplate. The various defogging compounds seemed to work well in most cases, however with some individuals, fogging was a particularly annoying problem. The possibility is suggested of modifying existing suits so that an increase in the flow of oxygen over the faceplate might alleviate the fogging problem. Regarding the g-suit connection, the problem

seems to be that the portion of the g-suit hose from the g-suit itself to the opening in the Mark IV full pressure suit is not secured to the full pressure suit until the connection to the aircraft is made. This requires considerable effort and several contortions on the part of the pressure suit wearer to achieve proper mating of the two g-suit components. It is suggested that the connection between the inner g-suit hose and the full pressure suit be modified to enable the wearer to secure these two components together while donning the Mark IV full pressure suit.

IN-FLIGHT MONITORING SYSTEM

The second phase of the aeromedical appraisal of the F4H-1F/SPARROW III weapons system involved in-flight monitoring of various physiological parameters utilizing portable magnetic tape recording. All possible flights in F4H, F3H, F9F, F8U, and TV aircraft were monitored. Pertinent to this report are the 16 monitored flights in F4H aircraft which will be reported below. Data were obtained during these flights by monitoring either the pilot or the radar operator in various stages of performance of missions involving both launch and captive flight of the SPARROW III missile. It was decided at the onset of this program that the electrocardiogram (ECG) furnished the most reliable index of stress of which current state-of-the-art techniques allowed dependable and meaningful monitoring at this time. Therefore the system to be outlined was built around the concept of monitoring in-flight electrocardiograms with a view toward monitoring additional physiological parameters as proper techniques are developed within our division. The system used for recording will be outlined below.

Design Criteria

The predesign study, in which the requirements, limiting factors, and available hardware were individually and collectively considered, resulted in the establishment of the following design criteria:

a. Five date channels would be recorded consisting of three ECG leads, one electroencephalogram (EEG) lead, and one voice correlation channel.

b. One lightweight miniature magnetic tape recorder would be used to record all five data channels simultaneously.

c. The instrumentation package would be self-powered.

d. Subminiaturized components would be employed.

e. A multiplexer unit utilizing FM techniques would mix five data signals (spectrum sharing).

f. Inter-Range Instrumentation Group compatibility would be achieved.

g. Cost would be minimized.

h. Environmental characteristics would be compatible with the current state of the art, commensurate with the time scale allotted for development of package.

Description of the Recording and Play-Back System

The system includes electrodes and electronic preamplifiers which are worn on the subject and a multiplexer/recorder package which is mounted in the aircraft. Voice correlation is introduced by cable from the AN/ASQ-19 communications navigation instrumentation (CNI) gear unit 7.

Electrodes and Lead System

The electrode is a state-of-the-art device developed in the bio-medical laboratory. It is a "floating" type, consisting of adhesive-coated cork components for mounting on the body, with a silver and silver chloride pellet for electrical pickup through a conductive gel from the "source" at the skin surface.

A lead system for monitoring a dynamic cardiogram was also developed in this laboratory. This system was developed to minimize artifacts encountered caused by muscle action potential interference while allowing recording of a three-lead, three-dimensional vectorcardiogram. This system is illustrated in figure 2 and described below. Lead system and electrode placement were designed as follows:

a. X axis - The horizontal component of the vectorcardiogram was obtained by monitoring potential difference between electrodes on the right and left sides of the chest. The electrode on the right side of the chest was attached at the level of the fifth rib, one-third of the distance from the mid-axillary line to the anterior-axillary line as viewing the body from the right side. Potentials from the left side of the chest were picked up by connecting in series through two 50,000-ohm precision resistors, two electrodes, one located in the fourth intercostal space and the other in the sixth intercostal space; both electrodes being located also one-third of the distance from the mid-axillary line to the anterior-axillary line as seen by viewing the body from the left side. This horizontal lead was designed so that an upward deflection in the ECG write-out device would be obtained when the electrodes on the left side of the chest were positive with respect to that on the right.

b. Y axis - The vertical component of the vectorcardiogram was obtained by recording the difference in potentials between two electrodes located on the back, both 3 cm to the left of the mid-line, one at the level of T_1 and the other at the level of L_5. This lead was also designed so that positivity of the L_5 electrode was represented by an upward deflection in the ECG write-out.

c. Z axis - The sagittal component of the vectorcardiogram was recorded by electrically tying together, through 5,000-ohm decoupling resistors, the four X and Y recording components noted above and utilizing this common terminal as a reference point with a recording electrode for the sagittal component of the vectorcardiogram located on the back 3 cm to the left of the

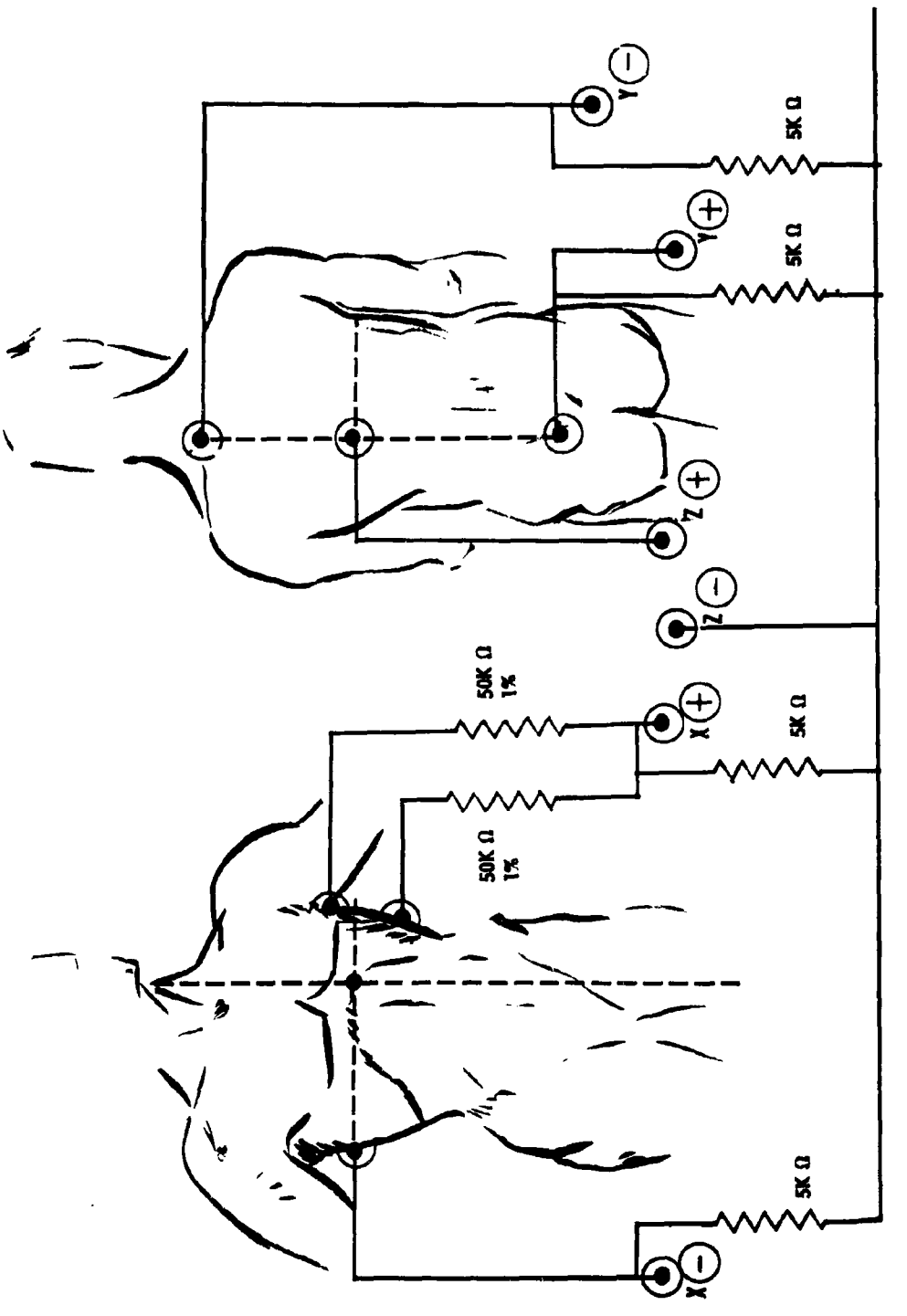

Figure 2. Schematic of Lead System Devised to Monitor the In-Flight Vectorcardiogram.

mid-line at the level of T_8. The system was so oriented that positivity of the recording electrode with respect to the reference common terminal resulted in an upward deflection in the electrocardiogram. It is felt that this common terminal approach to this third component of the vectorcardiogram is valuable for several reasons. First, it ties together four points on the body which are relatively distant from large muscle masses and hence are relatively refractory to muscle action potential artifacts. Second, it was found that the common terminal obtained as outlined in this text is virtually indistinguishable from the conventional, clinical common terminal referred to as "Wilson's common terminal." This gives this laboratory a distinct advantage in that utilizing this common terminal, any unipolar electrocardiographic leads which can be recorded clinically and in the static state can be recorded also with the subject engaged in almost any sort of activity.

This lead system was found to be fairly reliable, orthogonal, readily interpreted, and quickly and easily applied.

Preamplifiers

Preamplification was accomplished in the Litton type B30-A subminiature transistorized units supported, integral with a battery power supply, in a flexible cloth belt worn about the subject's waist. Appropriate Microdot fittings were mounted for umbilical connections to the multiplexer/recorder unit bracketed in the F4H cockpit.

Multiplexer

This device is a subminiature solid state, printed circuit modularly constructed, multichannel, voltage-controlled oscillator system with appropriate amplification in mixing stages for introduction of the CNI communication signals into a composite for acceptance by the recorder. From 80 to 2,000 cps at the low end of the recorder spectrum is allotted to voice, while IRIG channels 8, 9, 10, and 11 fill up the remainder of the usable spectrum of 80 to 8,000 cps.

Recorder

The tape recorder is a subminiature device with self-contained batteries which is mounted integral with the multiplexer in a rack just forward of the map case on the starboard cockpit console of the F4H. The recorder is a subprofessional device originally intended primarily for voice and music type data. The subprofessional nature of the machine necessitated a program of evaluation and upgrading by the Bio-Medical Division in an effort to adapt it to the recording of instrumentation type analog data. About nine significant modifications were accomplished which upgraded the machine to a marginally satisfactory status for deposition of bio-medical data. This upgrading information will be contained in a detailed separate report forthcoming from the Bio-Medical Division.

Playback System

The playback or readout system is composed of the four-channel discriminator, four-channel spectrum filter, and a Sanborn 350-1600 direct writer, with options of monitoring by oscilloscope or audio playout of both physiologic data and CNI voice communications. The discriminator is a solid-state, four-channel item with integral tape speed compensation incorporated. The flexibility of operation was emphasized in its design to improve accommodation of the frequently marginal characteristics of in-flight tape records. Speed compensation, however, deletes one channel of physiologic data.

The data-spectrum filter is an adjustable-frequency, single-slope, low-pass, four-channel device to function in conjunction with the output characteristics of the discriminator. Undesired artifacts in the analog data record consisting of many types of electronic noise and physiologic muscle tension output can be attenuated without serious degradation of the 0.5-cps to 60-cps coherent data spectrum. For data readout, a Sanborn model 350-1600, six-channel writer is employed. Heat- and pressure-sensitive chart paper is utilized with six analog channels. Optional readout is accomplished on long-persistence oscilloscopes where permanent records are not required. Aural perusal of both physiologic data and CNI communications can be attained by wide-band amplification of the entire recorder's spectrum with speaker output. To negate either physiologic or CNI data, a Krohn-Hite 310-A variable band-pass filter is applied between recorder and amplifier with a data crossover frequency at 2,000 cps.

Procedures

Operational routines chronologically fall into three categories; pre-flight, in-flight, and post-flight. The pre-flight portion of the routine supplies a record of non-stressful physiologic data, calibration information, and general assessment of system merit. The electrodes are attached first and the quality of this operation is partially indicated on console-mounted, specially designed equipment which reads out the ohmic value of each physiologic lead configuration, the lead contact potentials, and the belt pack battery potentials. Direct electrode-to-Sanborn-writer mode of operation is employed next. This system delineates the normal base line status record for the operation. It also serves as an assessment of the merit of the full in-flight system by A-B comparison of the direct mode readout versus the circuitous route of the full in-flight system. Susceptibility to pressure artifact of the electrode application is also derived at this time by a "tap" test while the physiologic record is being recorded on the Sanborn model 350-1600. The in-flight portion of the record is obtained with a pilot or radar operator in the aircraft and the multiplexer/recorder mounted in its bracket. Approximately 20 minutes of time is available on each tape magazine of the recorder. An additional 20 minutes is available if the pilot or radar operator has the opportunity to reverse the tape magazine position. Three types of data are desired on each mission; pre-launch/captive non-stressful, launch/captive stressful and post-launch/captive non-stressful. Compromises to this ideal

generally occur because of the "non-interference to operations" nature of the bio-medical mission. The post-flight routine is a repetition of the pre-flight phase with respect to measurements conducted and data recorded. Also, the aeromedical form report mentioned previously is generally filled out at this time and plugged into a computer system for later use.

Results and Comments

Gross conduction defects did not occur at any time during this study. Only gross and obvious defects of this nature can be discussed at this time. Rates rose from normals of 65 to 80 during pre-flight to a maximum of 180 beats per minute during more stressful phases of operations. All of the recorded complexes originated in the sino-atrial node and were all conducted through the atrio-ventricular node on the usual path. No arrythmias were noted, other than the sinus tachycardia noted above.

Rate proved an excellent index of the stressful nature of the mission and correlated directly with the task at hand. For instance, an average of 75 beats per minute was recorded during pre-flight checks, 90 to 100 beats per minute during pre-launch phases, 130 to 180 during launch phases, and rates of 90 to 110 beats per minute while returning to base.

It was noted that there were individual differences among participants in this program as might be expected. That is to say, the heart rates of some participants were accelerated more than others. No significant difference could be noted in the data obtained from pilots as opposed to those obtained from radar operators, and both showed equivalent increase in heart rates depending on the mission at hand.

No adverse effects of these very rapid rates were noted. These data fit in with available Air Force data compiled in the X-15 and X-100 aircraft.

CONCLUSIONS AND RECOMMENDATIONS

It is obvious from this investigation that more work needs to be done on refinement of a full pressure suit which allows more activity while in the pressurized state and, in the suit currently in use, it is recommended that an effort be made to improve visibility which is impeded by both reflections and fogging. It is suggested that in individual cases, oxygen flow over the faceplate may be increased, thereby enhancing evaporation of any moisture which may collect on the faceplate. It is also suggested that a device be designed to couple the g-suit hose to the full pressure suit during the donning of the suit so that function of the g-suit will not be lost be accidental decoupling during operations.

Data obtained by in-flight recording during launch operations have indicated that sinus tachycardia is encountered which (and this is speculation) would

probably incapacitate the participant if it were maintained over several days. However, during the brief periods in which it is encountered, this condition is not detrimental to the function of the pilot or radar operator as far as can be determined with the parameters monitored. Monitoring of more physiologic parameters is indicated to investigate this possibility. It is suggested that an upgrading of the bio-medical monitoring system is indicated and efforts are being made in this direction. As mentioned above, this division is endeavoring to upgrade the in-flight recording system and also work is going on to enable monitoring of flows and temperatures in and out of various portions of the full pressure suit, concentrations of various gases in and out of the full pressure suit, respiratory rate and depth, blood pressure, and electroencephalograms. Efforts are also being made to further refine our data-acquisition system so that more data may be obtained from the electrocardiogram.

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